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Procedia Engineering 44 (2012) 1716 – 1717

Procedia Engineering

www.elsevier.com/locate/procedia

Euromembrane Conference 2012

[P3.023]

Evaluation of nanofiltration membranes for sugar reduction in red grape must

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Since last years have been warmer and dryer in some regions, an early ripening of grapes takes place, which increases sugar content and, therefore, the alcohol content of wines. An adequate control of sugars in grape musts can be very useful to keep the alcohol degree of the resulting wines within the desired range. One mild and highly specific technology requires the use of membrane processes, such as nanofiltration (NF), to obtain low-alcohol wines by controlling the concentration of sugars in the must before fermentation [1]. Previous experiences on grape must NF showed that there are some problems, common in membrane separation processes, among them the especially relevant were those related with the permeate flux (J_v) decline [2]. This reduction in J_v is attributed to the phenomenon of concentration - polarization due to the accumulation of retained solutes near the membrane surface. The two fundamental factors that justify this are the osmotic pressure increase and the evolution of the total membrane system resistance, $R_{sys}(t)$ [3].

The aim of the present work is to select the most appropriate membrane for sugar reduction in the NF of red grape must. The selection criteria will be based on a membrane with high permeate flux, an appropriate sugars true retention (around 0.5), R_i (i= glucose and fructose), and a low affinity to high molecular weight compounds in order to not alter substantially its retention characteristics due to the accumulation of these compounds on the membrane surface.

For this purpose 3 NF membranes were studied in a flat sheet crossflow module: NF270 (Dow Filmtec), HL (GE Water), and KMS SR3 (Koch Membrane System). In order to analyze, individually, the influence of the high and low molecular weight compounds (HMW and LMW) present in must, on the J_v decline, the R_{sys} increase and the membranes R_i, the following procedure was performed for each membrane:

1. The NF of a synthetic solution (SS) containing the typical LMW of natural must: glucose, fructose, malic and tartaric acids, potassium, sodium, calcium and magnesium. The time evolution of J_v and sugars concentration were measured.
2. Calculation of R_i and the resistance due to the fouling caused by the reversible or irreversible adsorption of LMW on the membrane surface (R_{fLMW} (t)).
3. The NF of commercial red grape must (RM), which also contains HMW such as polyphenols, polysaccharides and proteins.
4. Calculation of the resistance generated by the formation of a gel layer on the membrane (R_{fHMW} (t)) and of the new R_i, both due to the presence of HMW.

The Jv time evolution of SS filtrations showed that the NF270 membrane had the highest flow followed by SR3 and HL. The main differences were appreciated mainly at the beginning of the RM NF, were the NF270 and the HL had almost the same fluxes while the SR3 membrane reached significant higher (3 times) values.

True retentions of glucose and fructose for the SS and for the RM as a function of time are shown in Fig. 1 a and b respectively. Both sugars were equally retained specially by the NF270 and the SR3. For the SS (Fig. 1a), the SR3 retention values seemed to be around the appropriate range (0.43 – 0.54), but the presence of HMW (Fig. 1b) altered this characteristic mainly in this membrane (from 0.18 – 0.88).

doi:10.1016/j.proeng.2012.08.920

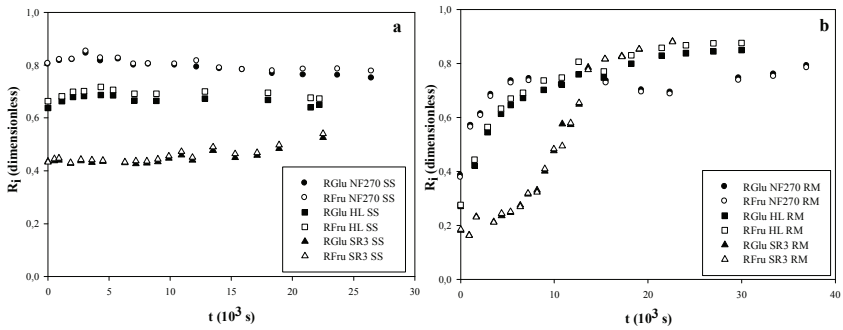

Figure 1. True glucose and fructose retentions as a function of time for SS(a) and RM(b)

Finally, the resistances to J_v due to the presence of LMW (R_{fLMW}) and HMW (R_{fHMW}) were determined and analyzed individually. As expected for the three membranes, R_{fHMW} had more influence on the J_v decrease, but this phenomenon seemed to be lower in the SR3 membrane. Furthermore, this membrane showed the smallest water permeability permanent loss after RM filtration, since it had the highest recovery after the cleaning procedure (93%).

Among the membranes studied, the SR3 seems to be the adequate for red must NF. Although its retention characteristic was the most altered during must NF, it presented the highest must J_v and the fouling due to the presence of HMW had less effect on its R_{sys}. These last two factors are important in must NF, since they enable shorter filtration times, which reduces the operation costs and the time that the must is being exposed to altering conditions. Besides this membrane showed the highest water permeability recovery, which reduces operations costs too.

Acknowledgements: Authors thank the MCINN for the financial through the research project CTQ2009-07666. C. Salgado wants to thank the ME for the FPU grant: AP2010-5769.

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Keywords: Nanofiltration, Sugar reduction, Red grape must, Low-alcohol wine